Steam System Control for Buildings Connected to MNDES
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Currently, 34 buildings are connected to the Metro-Nashville District Energy System (DES) utilizing steam produced at the Energy Generating Facility (EGF). Most buildings are connected in a similar manner with a few exceptions, which is very similar to that of district heating systems around the world. However, there are a number of different configurations that are also used depending on the parameters and requirements of both the building and the district system. Many articles have been published in various engineering journals regarding the pros and cons of each connection type.

The vast majority of DES steam customers utilize hot water for space heating. The balance of the customers use steam directly at their coils. Many of the DES customers also use steam to provide domestic water heating, in lieu of electricity or natural gas. Some of the customers use steam as a heat source in their laundries or kitchens. A schematic is shown in Figure 1 of the two basic connections types for DES customers.

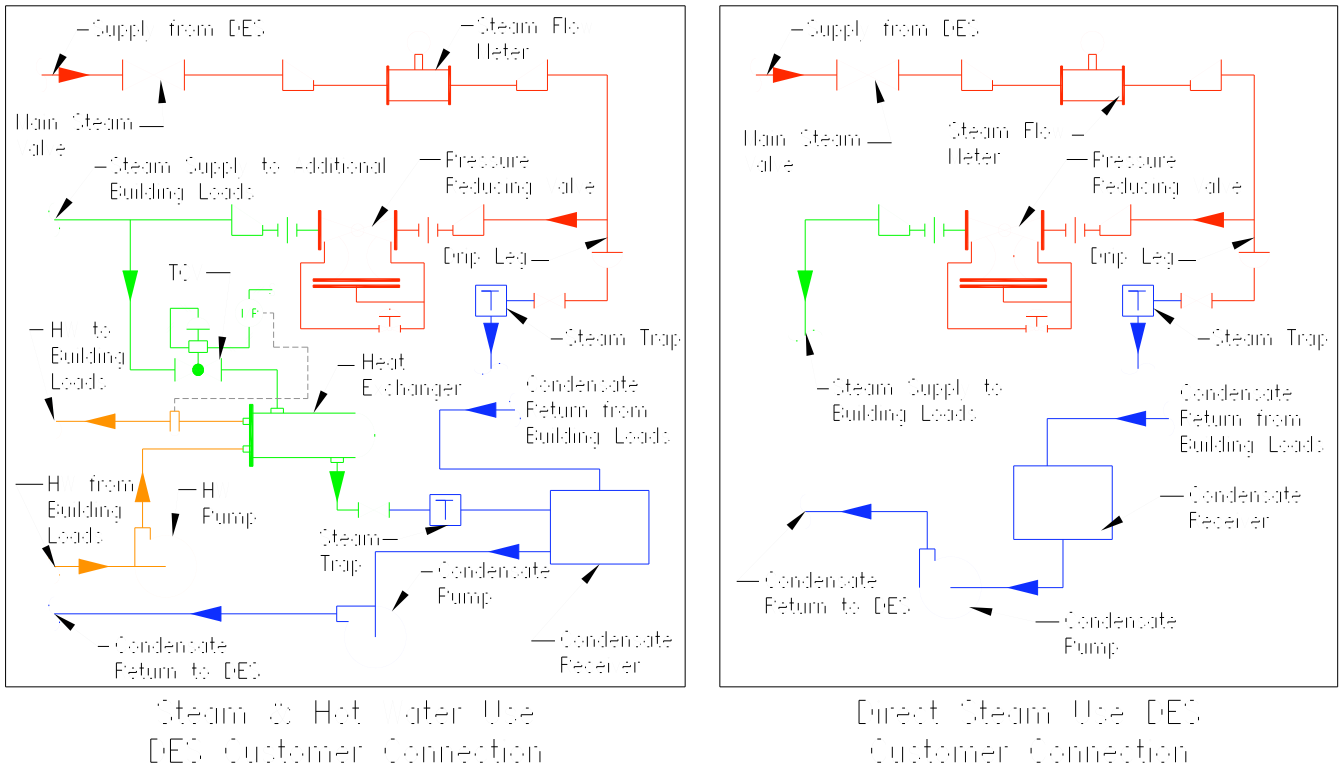

Figure 1. Typical DES Customer Connection Types

General Configurations

In general, the steam flow meter is located upstream of the pressure reducing valve at all DES customer connects. The pressure reducing valves serve to decrease and regulate the steam pressure within the buildings; however, the delivered steam pressure is typically between 145 and 150 psig and does not vary significantly. At some buildings, two pressure-reducing valves are required in accordance with the ASME B31.9 code if a safety relief valve is not installed and the steam equipment is incapable of withstanding the delivered pressure. Various drip legs with

steam traps may be installed at numerous locations between the building wall penetration and the pressure-reducing valve. These traps are necessary to remove condensate from the piping system to reduce the potential for water hammer and potential damage to the pressure-reducing valve and other valves, piping and fittings. The variations in customer connection types occur downstream of the pressure-reducing valve.

The condensate from the various trap lines throughout the building and from the heat exchangers and coils all return and collect at the condensate receiver. This tank serves as a means to collect and store the condensate in preparation for its return to the DES via condensate pumps. The receivers are typically sized to accommodate swings in steam demand throughout the year.

Steam and Hot Water Use Connections

The majority of DES customers have a connection similar to the one shown at the left of Figure 1. A shell and tube heat exchanger is installed downstream of the pressure-reducing valve to generate hot water for space heating and humidity control. Additional steam loads within the building may be served directly with steam or may utilize additional heat exchangers. The generation of domestic hot water with steam requires an additional heat exchanger and circulation loop.

The steam flow rate entering the space heating heat exchanger is controlled with a temperature control valve (TCV). This valve modulates to control the hot water leaving temperature. The operation of the TCV is fully automated, and some customers utilize an outside air temperature reset to adjust the leaving hot water temperature depending upon ambient conditions. The condensate from the heat exchanger is piped into the condensate receiver where it awaits return to the EDS.

The in-building hot water pumps are typically constant speed and circulate the hot water through the heat exchanger and the building coils to provide space heating and humidity control. Variable speed drives are used in some cases to provide a variable flow of hot water throughout the building. A localized control valve at each coil regulates the hot water flow rate through the individual coils.

Direct Steam Use Connections

A few of the DES customers do not utilize in-building hot water systems. Instead, the steam is used directly by the building heating system. Some of these customers do use heat exchangers for domestic water heating, but space heating and conditioning is accomplished with direct connections of steam to the coils at the air handlers and fan coils. A localized control valve at each coil regulates the steam flow rate through the individual coils.

Customers that use steam directly have extensive condensate return systems throughout their buildings and require multiple drip legs and traps to ensure the proper removal of the condensate. All of the condensate is piped to the condensate receiver where it awaits return to the EDS.

Condensate Return

Unlike the chilled water system, there is not a direct surcharge (TIFS) for returning condensate at an inappropriate temperature. However, a decrease in condensate return from any one customer affects all of the customers. High condensate return rates at relatively high temperatures improve the efficiency of the EGF by decreasing the amount of water make-up to the boiler system and by decreasing the amount of fuel required in the boilers.

Fuel (natural gas) is burned in the EGF boilers to produce the steam required by the customers and for in-plant use. The in-plant steam is used in the de-aerator to assist in the removal of the entrained gases from the steam, condensate and make-up water. With colder condensate temperatures, more steam is required in the de-aerator, thus more fuel is required in the boilers, decreasing the plant's efficiency. Also, with low condensate return rates, additional make-up water is required. This make-up water is much cooler than the condensate, thus more steam is required in the de-aerator. Both the lack of condensate return and low temperature condensate affect all of the customers by requiring additional fuel and water at the EGF.

In addition to the fuel and water required for a decrease in condensate return, additional chemical treatment of the make-up water is also necessary. The city water used for make-up contains chlorine, oxygen and other compounds that are detrimental to the operation of a steam system. The make-up water must be chemically treated to remove these harmful compounds in order to increase the longevity of the boilers, equipment and steam and condensate piping.

Demand Excursions

A frequent problem that occurs with steam systems is the occasional steam demand excursion beyond the contract demand. These excursions typically are caused by one or more of the following: 1) opening/closing the main steam valve, 2) inappropriately staging, or not staging, of equipment or 3) shutting equipment down during periods of low building occupancy.

Shutting down the heating system during periods of low building occupancy is a good energy saving measure, but care must be taken when the heating system is re-energized. When a building is allowed to cool and the steam system is re-energized, huge spikes in steam flow rate can be expected. These spikes in demand occur due to the extreme temperature difference between the air and steam or hot water. Occasionally, these high demands are sufficient to warrant an adjustment in the customer's steam demand.

To avoid these spikes in demand, equipment should be staged as it becomes re-energized. This scenario will reduce the total amount of steam entering the heating system. Staging is a sequencing process for starting or stopping equipment. The staging should occur with no less than 30 minutes between the activation of equipment to assist in avoiding spikes in demand. Also, re-opening of the main steam valve (or any downstream steam valve) should be performed very slowly. Building personnel can monitor the steam flow rates at the DX metering panels to empirically determine the rate at which the steam valves should be re-opened to avoid possible steam demand adjustments.

Summary

The majority of DES steam customers are connected to the system utilizing hot water heat exchangers for space heating. A few customers still use a direct connection of steam at their coils. Other customer uses for steam include domestic water heating and laundry and kitchen use. In either case, condensate should be collected and returned to the DES to ensure an efficient an operation as possible.

Excursions in steam demand can be avoided by properly staging equipment when recovering from periods of low building occupancy. This staging should occur over a minimum of 30 minutes to prevent unnecessary spikes in steam demand. Whenever the main steam valves, they should be re-opened as slowly as possible to prevent potential demand excursions.

There are a number of possible customer connection possibilities and potentially a number of improvements that could be made to your existing in-building cooling system that could result in an energy savings. An engineering evaluation is required to determine what those changes may be and their economic benefit to your building.